Feeding habits of Padogobius bonelli (Osteichthyes: Gobiidae) in the Curone Creek (Northwest Italy): territoriality influences diet?

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Feeding habits of *Padogobius bonelli* (Osteichthyes, Gobiidae) in the Curone creek (northwest Italy): territoriality influences diet?

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ABSTRACT

Padogobius bonelli in Curone Creek (Italy) fed mainly on aquatic insects, positively selecting Chironomidae, Simuliidae, and Hydroptilidae and negatively Baetidae, possibly related to the high mobility of the latter. When studying the variation of the diet with size, a positive correlation with some big prey items was detected. Nevertheless, no differences were detected when prey diversity was considered. Finally, the huge difference in the gut content among the individuals could be related to the marked territoriality of this species in the breeding season when this study was carried out.

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INTRODUCTION

The family Gobiidae is represented in Italian inland waters by five species that show different geographic distribution and ecological habits. *Padogobius bonelli* (formerly *P. martensi*) is an endemic fish of the Northern Adriatic area, distributed in northern Italy (Po and Adige basins) and Dalmatia (Gandolfi and Tongiorgi 1974). This fish inhabits fast-flowing and well oxygenated waters of streams with coarse substratum. This little Gobiidae reaches a mean length of 6-7 cm (exceptionally 9-10 cm) with benthic habits during juvenile and adult life (Zerunian 2002). The breeding season usually is from the beginning of May to early July (Gandolfi et al. 1991). This species shows high territorial habits in both sexes; individuals defend little areas in the substratum, with an evident preference for large cobbles and masses displaced in eroded habitats (Lugli et al. 1992). It is likely that these microhabitats provide good hydrological conditions, representing refuge from fast currents and areas with great amounts of food and dissolved oxygen (Gandolfi and Tongiorgi 1974). Usually the dimensions of the territory are proportionate to the size of the specimens, and many studies underlined the strong aggressive behavior of this species. As other Gobiidae, also this species shows acoustic communication mechanisms, particularly important in territorial and mating behaviors (Torricelli et al. 1987 and 1990).

Studies on feeding habits of the Gobiidae started with estuarine and marine species, and only in recent years have freshwater species been investigated (Miller 2003). Generally, Gobiidae are considered to be benthic feeders, with a diet dominated by crustaceans and molluscs (Charlebois et al. 1997). It is well known that some Gobiidae species are indiscriminate feeders, ingesting amounts of sediments and associated organisms (Carle et al. 1982), while many others show trophic preferences. For example, Adámek et al. (2007), analyzing the diet of four species from southern Slovakia, reported that diet partly differed among them and that Amphipoda, Chironomidae, Trichoptera (*Hydropsyche* sp.) and two Ephemeroptera nymphs (*Ephoron virgo* and *Potamanthus luteus*) were the most important food items contributing to the similarity of the diets of the studied species. Amphipoda represented the most important food item also in another

Gobiidae, *Neogobius gymnotrachelus*, followed by Chironomidae and, to a lesser extent, Ceratopogonidae, Oligochaeta, adult Diptera, and Copepoda.

Padogobius bonelli is generally considered a benthic predator, feeding on stream invertebrates and fish eggs, but little information is available about its diet. The aim of our study was to analyze the diet of *P. bonelli* in an Apenninic lotic system, investigating the existence of feeding patterns, preferences and variations in relation to the size.

METHODS AND MATERIALS

Forty specimens of *Padogobius bonelli* were collected in May 2007, during the reproductive period of the species, in the Curone Creek (NW Italy), near San Sebastiano Curone (44°47'14''N, 9°04'02''E; 320 m a.s.l.). Dense woodlands with only a few small villages are in the catchment, affording a good environmental quality for the lotic systems of this area (Fenoglio et al. 2008, Bo et al. 2009).Total lengths were measured with a precision of 1.0 mm. Digestive tracts were removed, stored in 90% ethanol, and analyzed with light microscopy (60-100 x) . Food items were documented photographycally. Diet composition was expressed as number of food items found, and organisms in food were classified generally to genus or family level. Moreover, samples in the same reach of the stream were collected using a Surber net (20 x 20 cm; mesh 255 μm) to assess the presence and abundance of the taxa of the natural benthic invertebrate population. Samples were preserved in 90% ethanol. All organisms were counted and identified to genus or species level, except for Lumbricidae, Lumbriculidae and early instars of some Trichoptera and Diptera, which were identified to family or sub-family level.

To investigate the existence of feeding preferences, gut contents were compared with the natural composition and abundance of the macroinvertebrate community in the riverbed using the trophic electivity index of Ivlev (1961): E = (ri-pi)/(ri+pi), where ri = relative abundance of a particular taxon in the diet and pi = relative abundance of the same taxon in the benthic community. The index ranges from −1 to 1. A value of −1 means total avoidance, 1 indicates preference, and 0 indicates indifference.

For statistical analysis, STATISTICA software (StatSoft 2005) and SPSS 14.0 (Lead Technologies Inc. 2005) were employed. Possible correlations between size and presence of different items in the gut content were evaluated using a Gamma correlation test. The same test was employed to analyze the possible correlation between size and diversity of prey in the gut. A Jaccard's index was used for assessing the similarities between individuals. This index takes into account just the presence of the different prey and ranges from 0 to 1, being 0 total dissimilarity between individuals and 1 total similarity.

RESULTS AND DISCUSSION

All the analyzed had prey in their guts. Moreover, some females carried eggs, indicating that they were in the reproductive period.

Padogobius bonelli fed on macroinvertebrates, mainly aquatic insects (Table 1). The most important prey item was larvae of Chironomidae; they constituted a 60.6 % of the total ingested items and were present in all guts. Other important prey were larvae of Simuliidae, *Baetis* spp., Hydropsychidae, and Hydroptilidae. Among non-insect macroinvertebrates, only Ostracoda and Hydracarina were present in a relative high number of individuals. Unusual components of the gut contents were terrestrial Coleoptera, fish eggs, and seeds. Fine particulate organic matter (presence 15%), vegetal matter (7.5%), algae (15%), sand (25%), and gravel (2.5%) were found in a few individuals. Finally, one third of the individuals (35%) presented a variable quantity of animal matter that could not be identified.

When comparing the macroinvertebrate community composition with the five most important prey by means of the Ivlev's index (Fig. 1) clear preferences for Trichoptera Hydroptilidae and for Chironomidae and Simuliidae larvae were observed. Only Baetidae nymphs were negatively selected.

Some prey tend to be more common in the diet in bigger specimens. This was the case for *Isoperla* sp. (Gamma correlation= 0.927, $p< 0.05$), Heptageniidae (Gamma correlation= 0.837, $p< 0.05$), and Tabanidae (Gamma correlation= 1.000, $p< 0.05$). Also, vegetal matter was positively correlated with size (Gamma correlation= 0.630, $p< 0.05$). Indeterminate Trichoptera and larvae of Chironomidae were negatively correlated with fish size (Gamma correlation= -0.358 and -0.281, $p< 0.05$, respectively). Correlation between fish size and the diversity of consumed prey was not detected (Gamma correlation= 0.213, $p> 0.05$).

Finally, applying the Jaccard's index, it was observed that there was a low degree of similarity in the gut composition between individuals. Only 5.6% of the results were higher than 0.5, while no result was higher than 0.8.

The analysis of the gut contents of *P. bonelli* in the studied area shows that this species feeds mainly on aquatic insects, while Mollusca, Crustacea, and fish eggs are only present in their guts occasionally, contrary to that found in some other species of freshwater Gobiidae (e.g., Charlebois et al. 1997).

The relatively high percentage of fine particulate organic matter in the guts, together with a lower percentage of sand and gravel, is probably a consequence of the feeding method of this species that collects its prey directly from the riverbed, as do some other Gobiidae species (Carle et al. 1982, Charlebois et al. 1997). Possibly the same is true for vegetal matter.

It is an outstanding fact that *P. bonelli* selects mainly small and scarcely mobile macroinvertebrates (Hydroptilidae, Chironomidae and Simuliidae). Baetids, despite of their small size, were negatively selected, probably related to the difficulty of this fish to catch them.

The positive relationship between size and some prey, such as *Isoperla* sp., heptageniids and tabanids, can be explained by the limitation of small fishes for ingesting those big prey. This is a usual situation in fishes, with smaller individuals ingesting smaller prey simply because of mouth size imitation (Hynes 1970). On the other hand, there was no significant relationship between fish size and diversity of ingested prey, as has been demonstrated in other fishes (e.g., Werner and Gillian 1984, Montori et al. 2006).

The big differences in ingested prey among individuals, as shown by the Jaccard's index, could be related to reproductive behavior of this species. *P. bonelli* is markedly territorial during the breeding season (Bisazza et al. 1989), with antagonistic behavior based on direct attacks and production of aggressive sounds. It is likely that, in defending a delimited area of the riverbed, each individual captures the prey within that area. As macroinvertebrates are not homogeneously distributed, this can be the reason for the high differences observed in the diet. So, the diet of this species could be strongly influenced by its territoriality, at least in the breeding period.

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Table 1. Mean numbers of prey items in the guts of 40 *Padogobius bonelli*. S.D. = standard deviation; % = frequency of occurrence (percentage of individuals containing the prey item).

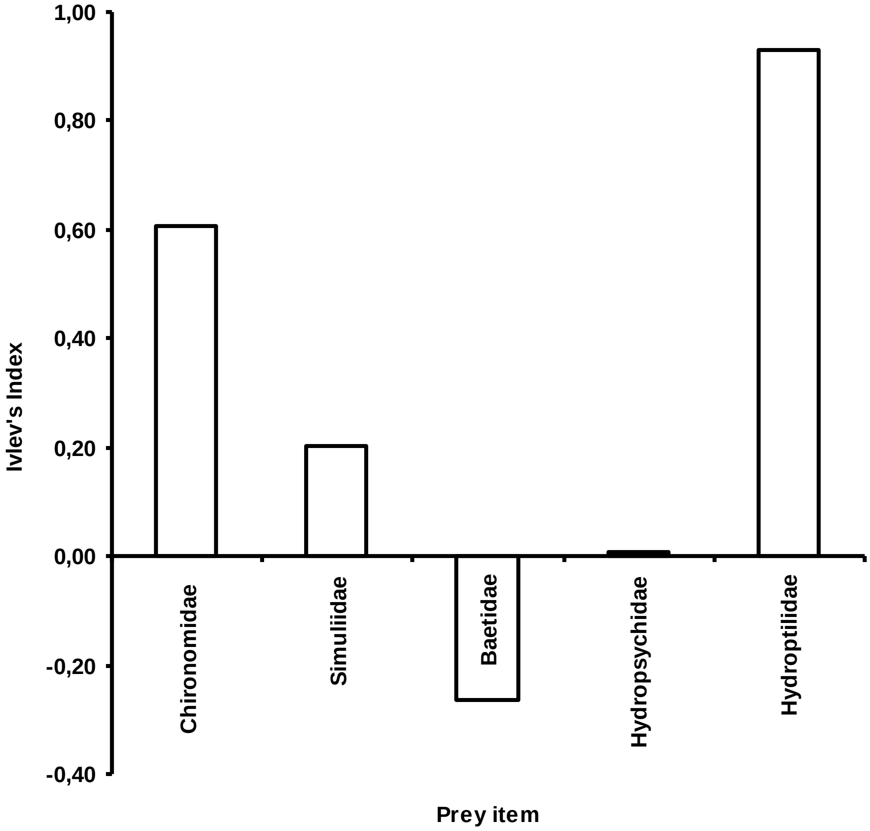
Taxon	Mean	S.D.	Min	Max	%
Plecoptera					
Leuctra sp.	0.02	0.16	0	1	2.5
Isoperla sp.	0.07	0.27	0	1	7.5
Plecoptera, unknown	0.02	0.16	0	1	2.5
Ephemeroptera					
Baetis spp.	2.22	3.33	0	18	67.5
Baetis spp. adults	0.15	0.70	0	4	5.0
Caenis sp.	0.02	0.16	0	1	2.5
Heptageniidae, unknown	0.20	0.69	0	3	10.0
Ecdyonurus sp.	0.05	0.22	0	1	5.0
Leptophlebiidae, unknown	0.02	0.16	0	1	2.5
Habroleptoides sp.	0.02	0.16	0	1	2.5
Serratella ignita	0.02	0.16	0	1	2.5
Ephemeroptera, unknown	0.47	0.96	0	4	30.0
Trichoptera					
Hydropsychidae	1.37	1.72	0	7	62.5
Hydroptilidae	1.10	1.66	0	8	50.0
Rhyacophila sp.	0.02	0.16	0	1	2.5
Sericostoma sp.	0.02	0.16	0	1	2.5
Trichoptera undet.	0.52	1.04	0	5	32.5
Diptera					
Chironomidae larvae	20.1	16.7	1	75	100.0
Chironomidae pupae	0.05	0.22	0	1	5.0
Chironomidae adults	0.02	0.16	0	1	2.5
Tabanidae	0.02	0.16	0	1	2.5
Tipulidae	0.05	0.22	0	1	5.0
Ceratopogonidae	0.02	0.16	0	1	2.5
Simuliidae	3.15	8.95	0	54	52.5
Limoniidae	0.02	0.16	0	1	2.5
Diptera undet.	0.02	0.16	0	1	2.5
Coleoptera					
Elmidae adults	0.02	0.16	0	1	2.5
Elmidae larvae	0.12	0.40	0	2	10.0
Terrestrial larvae, unknown	0.02	0.16	0	1	2.5

Taxon	Mean	S.D.	Min	Max	%
Odonata					
Onychogomphus sp.	0.05	0.22	0	1	5.0
Crustacea					
Ostracoda	0.55	1.17	0	6	27.5
Mollusca					
Lymnaea sp.	0.15	0.48	0	2	10.0
Arachnida					
Hydracarina	0.52	1.11	0	5	30.0
Others					
Fish eggs	0.02	0.16	0	1	2.5
Seeds	0.02	0.16	0	1	2.5

Caption to Figures

Figure 1. Ivlev's index results for the five most important macroinvertebrate prey items (all in the larval stage).

Fig. 1


1,00
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0,40
0,20
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-0,40
Ivlev's Index
Chironomidae
Simuliidae
Baetidae
Hydropsychidae
Hydroptilidae
Prey item